THE INSTITUTE OF PHYSICS
47 BELGRAVE SQUARE, LONDON, S.W.1.

BULLETIN

No. 51 MARCH, 1954

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APPOINTMENTS VACANT

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

Physicist for textile laboratory of rayon yarn production plant. Applicants should have good honours degree. Experience in the textile industry an advantage but not essential. Commencing salary £550 – £800 per annum, depending on experience and qualifications. Pension scheme. Applications, stating age, qualifications and experience to **Personnel Manager, British Enka Ltd., Aintree, Liverpool, 9.**

A **graduate physicist** is required to fill a senior position in a team concerned with work on the development of semi-conductor devices to operate at very high frequencies. A knowledge of microwave techniques would be an advantage. Apply in writing giving full particulars to the **Staff Manager (Ref. RLO/21), Research Laboratories, The General Electric Co. Ltd., North Wembley, Middx.**

A **senior physicist** or **senior research engineer** to take charge of Research and Development Section of Company allied to the electronic industry. Experience desirable in vacuum and production techniques, associated with valves, cathode ray tubes and oscillograph development. This post offers considerable scope and the salary paid will be commensurate with age and experience. Full details to Managing Director, Box No. A.V.56, The Institute of Physics, 47 Belgrave Square, London, S.W.1. All applications will be acknowledged.

Electronic Tubes Ltd., makers of cathode ray tubes, oscillograph tubes and radio valves, invite applications for the following vacancies within this organization :— (1) **Technical Assistants** preferably near degree standard in physics or engineering for development work associated with cathode ray tubes and radio valves ; (2) **Technical Assistants** or **Engineers** preferably H.N.C. or near degree standard for technical liaison duties in the production division covering radio valves and cathode ray tubes. Some experience in this industry or electronics desirable but not essential ; (3) **Physicists** in the grades of senior scientists and scientists for development work on oscillograph and cathode ray tubes and radio valves. Some experience in this industry or electronics desirable. Degree standard or member of approved institute preferred. Salaries for the above posts will be paid commensurate with age, qualifications and experience. Write giving full details of education, age and experience to the **Personnel Manager, Electronic Tubes Ltd.,** Kingsmead Works, High Wycombe, Bucks, quoting reference number of application sought. Mutual arrangements will be made for interviews and travelling expenses paid.

Vacancies exist for **Telecommunication Engineers** in the central laboratories of a large manufacturing organization. Good academic qualifications with a general knowledge of radio theory and application essential. A knowledge of radio propagation an advantage.

Applications should be addressed to the **Personnel Manager, Standard Telecommunication Laboratories Limited, Progress Way, Enfield, Middlesex.**

National Coal Board invite applications for the undermentioned superannuable appointments, at the Central Research Establishment, Isleworth, Middlesex. The work undertaken is on fundamental principles and staff are required for the following fields :—(1) problems in the control and improvement of working conditions in mines ; (2) mechanical properties of coal of relevance to coal winning ; (3) technical methods of coal winning ; (4) design of experimental coal-getting machinery ; and (5) instrumentation for use in mines and laboratory in connection with the above problems.

Scientists. Candidates should have a first or second class honours degree (or equivalent qualification) in physics, mathematics or engineering. Some post-graduate research experience cognate to the above studies is desirable and work in the following fields would be particularly applicable :—heat and thermodynamics ; properties of gases ; properties of matter ; elastic and plastic properties of materials ; strength of materials ; friction ; applied mechanics ; fluid flow ; design of experimental machinery and devices ; technique of measurement of stress and strain ; recording apparatus ; electronic circuit design.

Appointments will be, according to qualifications and experience, as either Scientist Grade II (£645 × £30 to £1,085 per annum male, and £545 × £25 to £795 × £30 to £945 per annum female), or Scientist Grade III (£445 × £25 to £845 per annum male and £420 × £20 to £720 per annum female). London Location Allowance of £32 10s. 0d. at the minimum rising to £78 per annum at the maximum of the scales, is payable in addition. Reference No. TT/743.

Physicists and **engineers** for appointments as Scientific Technical Officers. Staff are required for the field of technical problems arising in coal transport, roof support, etc., in addition to those fields quoted above at (1) to (5).

Appointments will be, according to qualifications and experience, as Scientific Technical Officers either Grade II (£485 × £20 to £705 per annum male, and £390 × £16 to £566 per annum female) or Grade III (£375 × £20 to £535 per annum male and £300 × £16 to £428 per annum female). London Location Allowance of £32 10s. 0d. at the minimum rising to £50 per annum at the maximum of the scales, is payable in addition.

Candidates should possess a pass degree (or equivalent qualification) for Scientific Technical Officer II posts and an intermediate degree (or equivalent) for Scientific Technical Officer III posts. Previous experience in laboratory work or instrumentation would be an advantage. Reference No. TT/744.

Write giving full particulars (in chronological order) of age, education, qualifications and experience (with dates) to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope with relevant TT reference No. quoted above. Closing date April 9, 1954. Original testimonials should not be forwarded.

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THE INSTITUTE OF PHYSICS

No. 51 **BULLETIN** MARCH, 1954

UNDERGRADUATE PHYSICS

By J. THOMSON, M.A., D.Sc., F.Inst.P.

" *That which man altereth not for the better, Time, the Great Innovator, altereth for the worse.*"

Francis Bacon.

Since the end of World War II there has been a steadily increasing demand for more courses of approximately University standard in physics and applied physics. From time to time the emphasis has shifted, on occasion towards a demand for severely technical instruction, and on occasion towards a demand for real post-graduate training, but disregarding all controversies regarding what exactly is required and exactly how the situation should be met, there is no doubt that there is a real need for more physicists and for better educated physicists.

The reasons for this demand fall into two categories. On the one hand the post-war expansion of science in industry has produced a market for talent which is not yet saturated. On the other hand, owing to the effects of two disastrous wars in the last half-century, there is a scarcity of leaders in physics as in every other field. Even the Universities are affected by this scarcity, and have been since 1918, when many of their brightest and best failed to return. In assessing the dimensions of the educational problem posed by the increased demand it is well to bear in mind that due to no fault of their own the Universities, like other organizations, have been working with a depleted intellectual stock for thirty odd years. A country does not easily recover from a holocaust such as World War I as far as leadership is concerned.

ASPECTS OF THE PROBLEM

The problem created by the increased demand for physicists has many aspects, and there has been much discussion of some of them. For example, the intellectual potential of the nation has been assessed, and with certain assumptions it has been demonstrated that we are not likely to obtain a major increase in the number of young men qualified to enter a University. Another aspect of the problem which has given rise to some controversy is concerned with the facilities available at Universities and Technical Colleges for teaching applied physics, while the nature of the courses to be given to physics students is a perennial subject for discussion.

All approaches to the problem have been conditioned by an assumption—one might almost call it a fear—that the subject of physics is now so huge and ponderous that it can only be adequately treated by specialization. Continually in discussion one hears the complaint that there are only x years in which to complete the course and there are y items which must be considered, and that the ratio x/y is of course much too small for adequate comprehension. It is not hard to understand why teachers tend to be over-awed by the magnitude of their task, for it is a simple fact that every natural and artificial phenomenon has its "physical" aspect, and presents "physical" problems. Indeed it is in this universality of physical concepts that the great joy of teaching physics resides, and presumably one ought not to cavil at the incentive to one's activities. Even the names of the various branches of physics can be almost frightening, and it appears certain that much of the trepidation and caution displayed in attempts to solve the problem of more and better physicists springs from the defeatist attitude of those who say that a student can only learn so much in a given time, implying that "so much" is not by any means enough.

ANOTHER ASPECT

There is another aspect of the problem which may not have received the attention it deserves. How far have University teachers attempted to bring their systematic courses into line with modern physics? They, themselves, know that the discoveries of the last hundred years have enormously simplified our concepts of the physical universe, but have they imparted this knowledge to their students? Has there been a revolution in University teaching corresponding to the revolution wrought in our physical comprehension by the now completely accepted general theories of the electronic structure of matter, or do Universities still teach Heat, Light, Sound, Electricity and Magnetism, in roughly water-tight compartments with an occasional cross-reference but no real integration? The universe of physical science is so beautifully simple, explicable as it is in terms of a few well-defined rules which apply equally to all physical phenomena, that it appears a pity if it cannot be made known to an increasing number of students by a study on the part of their teachers of how to present it.

In writing this the author is well aware that he is guilty of two most heinous sins; first in stating that physics is a simple study which was what was said by Faraday, Joule and Maxwell and is denied by many modern metaphysicians, and secondly, in throwing aside the veil of the mysteries and suggesting that modern physics is a logical body of doctrine. The author will remain unrepentant. Leaving aside the high-priesthood, modern physics is much simpler than classical

physics ever was, and its logic appeals immediately to the uninitiated, when they realise the beauty of the self-consistent structure to which it gives rise.

UNIVERSITY TEACHING

In the " good old days " when University Professors had time to teach their subject and to occupy themselves with researches, it was the object of every physicist to present his subject in the most logical fashion possible. It was the delight of the classical physicist to bind all his phenomena together by the mortar of a few principles and to deduce new applications for further experiment. This we continue to do in our research laboratories, but it is not at all clear that there is any determined attempt to do it in the class-rooms. Perhaps it is because Professors now-a-days are administrators, but whatever the reason it is having disastrous effects on our graduates. In the author's opinion the structure of University physics courses should be overhauled to bring them into line with modern thinking. The phenomena usually considered in a course in Heat should fit automatically into a discussion of the structure of matter which is the real subject of physics. Similarly the phenomena discussed in Geometric and Physical Optics fall neatly into place when there has been a preliminary exposition of the nature of radiation and its relation to matter. If the old text-books are taken as illustrations of the application of the principles of the new physics, students will emerge with a comprehensive grasp of the nature of the physical universe which will startle their tutors.

All this sounds much too facile to be true. The writer admits that it is not so easy in practice to weld every phenomenon into its correct niche in the structure. He is even prepared to admit that there are certain phenomena which cannot be accommodated. The metaphor is a poor one, for physics is more akin to a living organism than to an inorganic structure, and new phenomena are assimilated rather than attached. But by and large our present concepts of the nature of the physical universe make extremely good sense. Can we demonstrate this to the enquirer ?

A University course might well begin by giving students a picture of matter in its various states. This picture would have to be painted brightly and roughly on a large canvas. The properties of matter, including in this category the storage and transfer of kinetic energy, the elementary facts about electric conduction in metals and semi-conductors, and the transmission of mechanical vibrations, would then emerge naturally as topics for discussion. A more detailed study of atoms and molecules would introduce the concepts of emission and absorption of energy and bring to notice the electromagnetic spectrum. The detailed explanation of the phenomena encountered during the

journey through physics would demand a study of the elementary laws of electromagnetism, the basis of modern physics, and this study would have to be undertaken in parallel with the main journey in order that the student's tour of the Universe should have its full educational value.

Within the scope of an article such as this it is impossible to do more than sketch the possibilities. Essentially the object of a University course should be to evoke the appropriate response from the student, and the stimulus must be as complete a description as it is possible to give of the inter-relations of physical phenomena. It is amazing how few graduates realize that the special theory of relativity is implicit in the laws of electromagnetism : that surface tension in a liquid is electrical in origin : that phase coherence is the exception rather than the rule in electromagnetic waves ; or that there is no incompatibility between the ballistic and wave-theories of electron motion.

It must not be imagined from the above that the author favours more time being spent on systematic teaching at Universities. All that is implied is that any teaching which is given should be along the lines suggested. Nor should the principle be applied with such wholehearted vehemence in schools. The evidence is that school physics teachers are already very progressive, and in any case it may well be that what has been suggested above is not so applicable to School teaching. It is in the Universities that the trouble lies.

THE DEMAND FOR PHYSICISTS

Returning to the subject of the opening paragraph, it is contended that the best method of meeting the demands of British industry for more and better physicists would be to improve the standard of comprehension of physical principles in the graduates emerging from our Universities. This cannot be a complete answer to the problem, for there are several grades of physicist required, but for key posts in industry the so-called " specialist " is not satisfactory in his present guise. Men who possess the ability to understand the underlying principles of action in any device or phenomenon—men who can apply physical principles to diverse problems, none of which can be categorised by the academician—these are the men needed to solve our technical problems, and no narrow training in any technique will produce such men. That we have them now in many important posts is a credit both to themselves and to the teachers of a past generation. Let us not be afraid to re-adopt the methods of our fathers if these are proven to be superior to our own.

RESEARCH ASSOCIATIONS
V — THE BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

By G. L. J. BAILEY, Ph.D., D.I.C., F.Inst.P., F.I.M.

While the consumption of all the common non-ferrous metals added together falls far short of that of iron and steel, our civilization owes to them almost as much as to the cheaper and more abundant ferrous metals. One has only to think of copper conductors, aluminium airframes and cooking utensils, galvanized steel, tinplate food containers and of lead water-pipes and cable sheaths to see illustrated some of the special properties through which these metals make their essential contribution to our attempts to live in civilized communion.

This country is not richly endowed with natural resources of the non-ferrous metals, for supplies of which it is fortunately able to rely largely on other Commonwealth countries. Its wealth lies rather in the possession of a concentration of skills and capital equipment for refining the metals, melting their alloys and producing semi-fabricated shapes—wire, sheet, tubes and extruded forms—to meet the varied demands of engineering practice. There is also a substantial effort engaged in the production of engineering castings and of galvanized, tinned and electrodeposited coatings.

With several basic metals and so many divergent uses for them it is not surprising to find a large number of firms in the field, and to discover a wide range of size among these firms. A few are large enough to run effective research organizations on their own account, but many are unable alone to support the cost of such a necessity. There is thus ample scope for a research service run on co-operative lines, the more so when one remembers that modern industrial metallurgy is the descendant of ancient crafts to which analytical methods calling for a knowledge of the basic structure and properties of matter are only now being applied. The research worker feels a challenge to explain why the efforts of past empiricism have succeeded or failed and in doing so paves the way to further advances in the practice of industrial metallurgy.

AN INDUSTRIAL PROBLEM

An example from the recent work of the British Non-Ferrous Metals Research Association illustrates the point well. An alloy of aluminium with about 3% of magnesium, in sheet form, is favoured on account of its mechanical properties for pressing into shapes such as refrigerator door panels. The material has the unfortunate habit, however, of yielding irregularly during stretching on the large expanse of such panels which undergoes only slight extension and bending.

This is distressing because the " stretcher-strains " produced as a result of the yielding mar the appearance of the panels to an extent which is not always masked by any coat of paint which may be applied. The only remedy, an empirical one, has hitherto been to ensure that the grain size of the polycrystalline sheet exceeds a critical value. But this calls for a nice control in production because if the grain size somewhat exceeds the critical value another type of surface defect, descriptively termed " orange peeling," becomes intolerable.

The phenomena of stretcher-strain markings occur in steel also and have there been associated with the sudden yielding which occurs without increase of load when a strip of the steel is stretched beyond a certain point. The cause of this discontinuous behaviour forms the subject of academic debate. According to the view advanced by Professor Cottrell yielding occurs when the internal stress distribution is such that dislocations of the structure are torn away from the atmosphere of solute atoms, in this case of carbon, which tends to form a stable arrangement around them. If the rate at which carbon can diffuse through the iron lattice is low in relation to the rate of straining, there is only a single discontinuity in the stress-strain curve, but if the diffusion rate is high enough, repeated anchoring and tearing away of dislocations occurs and a succession of yields is observed in the stress-strain curve.

In investigating the aluminium-magnesium alloy, it was found at the Research Association that there were in this case two types of yield, distinguished by their relative size and by the appearance of the corresponding strain markings on the stretched specimens. One type occurred repeatedly during straining at room temperature and could be suppressed by reducing the temperature. This was attributed to the occurrence of strain-ageing as described by Cottrell, the anchoring atoms in this case being of magnesium. The other type occurred only once during stretching. It was larger than the others and occurred first. It could not be restored by prolonged ageing at room temperature and it returned only after treatment at temperatures causing the plastically-strained material to recrystallize.

It was also established that the Cottrell-type yielding was not affected by change of grain size, whereas the new type became more pronounced with decrease in grain size, and, having in mind the influence of grain size determined empirically in practice, it became clear that it was the new type of yielding which was responsible for the practical troubles. This was consistent with the fact that it occurred at small plastic strains, and that just such small strains are involved on the large flat surfaces of pressings.

The problem was then to discover means of suppressing this large single yield other than by adopting an uncomfortably large grain size.

It was already fairly obvious that one way would be to give the sheet a small amount of cold work to ensure that it had passed the initial yield before pressing. This should be done not by stretching a large expanse at one time, which would cause markings to appear, but by local plastic working such as a light rolling pass or " roller-levelling," which are in fact more convenient to apply. If this slight work-hardening interfered in the more severe pressing operations, it could be largely removed by annealing the sheet at a temperature low enough to ensure that it did not recrystallize. These remedies were wholly successful. But the cause of the new type of markings remained to be found, and in explaining them yet another method of avoiding them became apparent. It seemed clear that the troublesome yield was associated with the grain boundaries, presumably with some feature of their structure which hindered the transmission of slip from one grain to another. It was suspected that this hindrance might be due to a concentration of magnesium atoms in the lattice irregularities constituting the grain boundary structure. Such concentrations, while present in slowly cooled sheet, should be less marked in sheet quenched from a high temperature, which should thus be free from liability to markings of this type. This was found to be so.

The course of this investigation has been described at some length because it illustrates well the nature of a typical industrial problem and the fact that empiricism does not necessarily provide the most convenient solution. It was a case where even the largest private research organization might have felt the chances of success to be so small as not to justify attacking the problem in view of more urgent needs, and where in any case a number of manufacturers and users of sheet shared an interest in possible solutions. Finally, the example shows how the attack upon an industrial problem can both gain stimulus from the body of academic knowledge and in turn add to that knowledge while achieving a primary objective in the field of industrial practice.

There is in this example perhaps also a point worthy of note by physicists seeking a career in the fields of technology. To gain satisfaction in work of this kind the investigator concerned must have sympathy for the practical problem he aims to solve and an adequate knowledge of the technological background to it, in addition to the scientific discipline which guides his attack. The problem just described is one within the competence of a physicist to solve, given the background, but he will be less likely to do so if he fails to see why it is important in everyday life.

THE RESEARCH ASSOCIATION

The investigation of problems such as that just described which arise in connection with the extraction, refining, manufacture and

ultimate use of the principal non-ferrous metals of commerce constitutes the major activity of the Research Department of the B.N.F.M.R.A. This Association, which was one of the earliest of the industrial research associations to be formed, now employs a total staff of about 150 of whom some 40 are graduates, and is supported by the subscriptions of over 500 members. The subscription income is supplemented by Government grant administered through the Department of Scientific and Industrial Research. Its activities are controlled by a Council composed largely of industrialists prominent in the fields of metallurgical production and engineering, and containing also representatives from the service ministries, the universities and the D.S.I.R.

While the principal activity of the Association is research, and the Research Department is correspondingly large, there are two smaller departments, one the Liaison Department and the other the Information Department. The Information Department provides a loan service to members from its extensive library, arranges the distribution of the Association's research reports, prepares a monthly "Bulletin" of abstracts of current metallurgical literature and edits a monthly "Review" of the results of researches. The Liaison Department maintains contact with members on technical matters by assisting in the application in practice of the Association's research results, by providing a confidential advisory service on day-to-day problems and by drawing attention to problems which merit detailed investigation by the Research Department.

These proposals for research and others made by member firms and by the Association's staff are kept under review by the Research Board (a Committee of Council) whose function it is to authorize new investigations. When an investigation is undertaken it is usual to form a small advisory technical committee, drawn from the industry, to define the problems precisely and to comment on the course of the investigations.

Thus the investigator is made aware of the background to his problem and reminded of his objective, while being left free to attack it in his own way.

Internally, the Research Department is arranged in seven Sections, each under a Head of Section and staffed by three or four graduates with a number of assistants. These Sections are: Melting and Casting, Mechanical Testing, General Metallurgy, Chemical and Electrochemical Finishes, Corrosion, Physics and Chemistry. All are served by the Library, by a workshop and by a clerical pool and each, besides responsibility for the research projects which fall most appropriately to it, serves member firms through the Liaison and Information Departments and also provides service for the remaining

Sections. In this way every investigator can spend a proportion of his time as an active member of a large team interested in a wide range of problems and so broaden his experience and avoid undesirably narrow specialization.

The Melting and Casting Section includes in its programme investigations which have a bearing on extraction and refining practice, but is mainly concerned with foundry work. As an alloy cools in the mould it rejects gas held in solution at higher temperatures ; it may pick up further gas released by reaction with moisture at the mould walls ; there is segregation of the metallic constituents as the crystals of solid grow, and there is contraction accompanying the cooling. It is not surprising that gas porosity, shrinkage cavities and gross tearing due to contraction can occur. In the past the Association has contributed many studies of the causes, mode of occurrence and control of these effects. Of particular interest in this connection are recent studies of the grain refinement of light alloy castings by the addition of constituents chosen to nucleate crystallization, and of the flow of heat from alloys of different solidification characteristics during the casting of basic shapes. The shrinkage of a casting on solidification must be made up from a reservoir or " feeder," which must be the last section of the casting to freeze and is therefore liable to be massive. The earlier work on heat flow played its part in the design of recent experiments showing how feeder sizes could be substantially reduced through the use of local insulation or of local exothermic reactions.

Another aspect of foundry practice of interest to physicists concerns the flow of metals into castings in a way which minimises oxidation of the metal and erosion of the mould, and here much remains to be done.

In the field of physical metallurgy with which the General Metallurgy and Mechanical Testing Sections are largely concerned there are many problems which centre in the relationships between alloy structure and deformation characteristics—either in fabrication or subsequently when subjected to stress in service. Such problems as the achievement of high rolling reductions with freedom from cracking, avoidance of directional properties in extrusions, production of highly creep-resistant alloys which are nevertheless ductile at low strain rates and the improvement of fatigue properties should ultimately find their best solutions from unified theories of deformation, but development in this direction must be slow in view of the complexities of the processes. Menawhile, practical progress must depend on studies of each problem in the light of such basic knowledge as may possibly be relevant. The example of stretcher strains in aluminium-magnesium

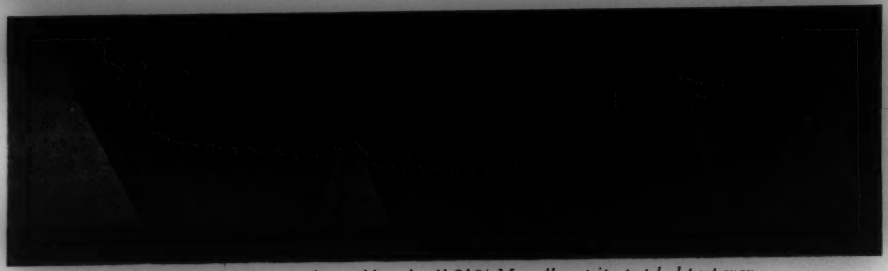

Fig. 1 — Stretcher-strain markings in Al-3½%Mg. alloy strip stretched part-way through the large initial yield (xl).

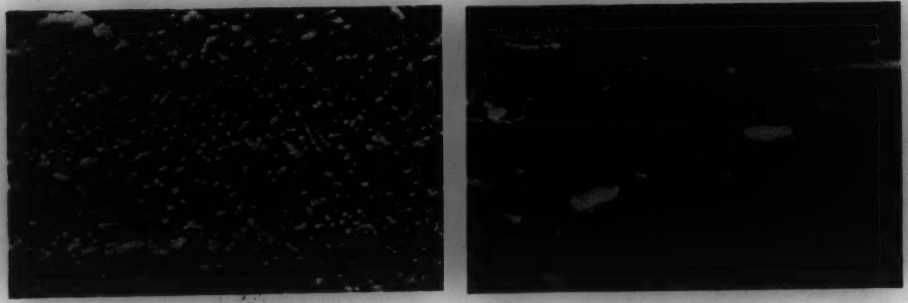

Fig. 3 — Nickel plating upon aluminium. Reflection electron micrographs showing (left) poorly, and (right) well-nucleated, layer of intermediate zinc deposit, overlying aluminium.

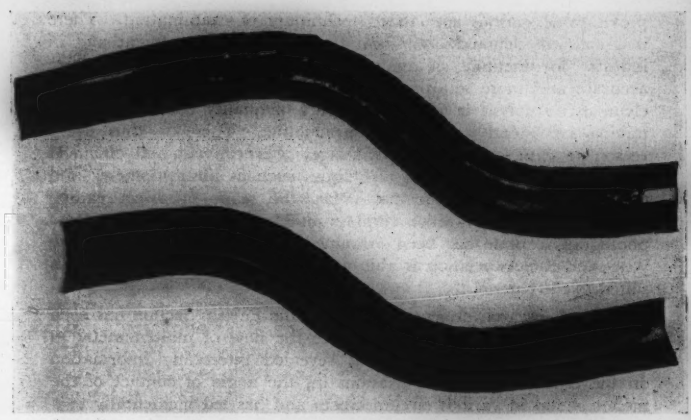

Fig. 2 — Longitudinal section through tubes of copper (above) and copper–5% nickel–1% iron alloy after exposure to flowing aerated sea-water for one month.

alloys quoted earlier shows what may be achieved by an approach which is informed by available knowledge of metallic structure.

In the Corrosion and Metal Finishing Sections the study of surfaces naturally predominates. One of the most successful corrosion investigations has been concerned with the development of copper-base alloys resistant to corrosion by sea water and suited for use in ship's main steam condensers and salt-water mains. Others are currently concerned with the corrosion of copper and aluminium in domestic supply waters and of non-ferrous alloys in gas-turbine heat exchangers. In all this work the sometimes powerful effects of surface films, produced during the manufacture of tubes, for example, has become clear and is always to be borne in mind. While the methods of physical chemistry provide the principal tools for studying corrosion problems substantial help is given from time to time by physical methods of examination such as electron-diffraction and microscopy and X-ray examination. This is also true of metal-finishing investigations where physical methods have recently given a greatly extended understanding of the sequence of events when aluminium is nickel-plated by established methods. Such deposits have been liable to adhere poorly, but new methods based on knowledge of the old eliminate this defect.

The Physics and Chemistry Sections differ from the remainder in devoting a higher proportion of their effort to service through the

provision of various specialized techniques of examination. There is a constant demand both from the Research Department and in industry for methods of analysis which are faster, cheaper, more accurate and more sensitive, or which extend to a wider range of elements. Analysis is an essential part of quality control in maintaining consistently satisfactory production. There is thus every reason to exploit fully the advantages over conventional chemical analysis offered by physical techniques such as absorptiometry and emission spectroscopy. In particular, the scope of direct-reading emission spectroscopy which employs photomultipliers in place of the photographic plate has been examined in detail over the past few years and the Association is able to advise its members on methods suited to their needs.

Among research projects handled by the Physics Section has been a study of the factors which promote the flow of molten metal in soldering and brazing. This has revealed interesting information on the influence of, and variations in, the angle of contact of the molten metal in various circumstances and has led incidentally to a determination of the absolute values of the surface tension of solid copper and the interfacial tensions between copper grains and between solid copper and molten lead. These are of interest in view of theoretical predictions and in connection with questions of recrystallization and grain growth. The work as a whole enables the conditions for producing sound joints to be more easily foreseen and provides tests for the performance of different combinations of solder, flux and basis metal. Its results are currently being applied in connection with problems of brazing at very high temperatures.

CONCLUSION

What has been said may serve to show how co-operative enterprise on the part of a heterogeneous industry, with many firms of different sizes, interested in several metals and with many forms of product, is conducted economically and efficiently with advantage to all. From the point of view of the staff, there is opportunity to gain a wide variety of experience and, within the limits of a defined aim to their work, to attack problems from elementary bases—in fact to pursue what Sir Edward Appleton has called "fundamental objective research." It is certain that the background thus being supplied to the processes of industrial metallurgy and the characteristics of its products is helping to keep the technical efficiency of the industry at the high level it must maintain to ensure future prosperity, and that in this way the industry is achieving for itself the purpose of those who first inspired the Research Association movement.

NOTICES TO MEMBERS

The Institute's 1954 Budget

A Budget of income and expenditure is agreed each year by the Board. For 1954 the expected cash income is almost £50,000, the two principal items being £34,000 from sales of publications and advertisements in the journals, and £11,750 from subscriptions of members. Items of expenditure totalling £46,100 have been authorized. The main expenses are £21,000 for the production of publications (excluding staff salaries and wages and other office overheads), £13,750 for salaries, wages and superannuation, and £3,500 for rent, rates, heating, cleaning and maintenance of the House. About one half of the total for salaries and wages is attributable to publications. From the estimated gross surplus of nearly £4,000, £900 will be used for writing off expenditure on alterations to and furnishing of the House, £985 will be paid as annual premium on the Leasehold Redemption Policy which will provide £40,000 in 1982 when the lease of the House expires, and £2,000 will be held as increased reserve offsetting the value of books held in stock.

In the few years after the end of the war, when the Institute leased, adapted and furnished the House and simultaneously embarked upon a large expansion of its publishing work, the Board decided to use most of the "liquid" assets of the Institute for the capitalizing of these developments. The reserves were allowed to become low but the justification of that policy is now becoming apparent. It is now becoming possible to begin to increase the reserves steadily as well as maintaining a widely extended range of Institute activities. At the same time the Board considers that it would be imprudent to undertake any new work that would involve financial commitment.

INSTITUTE CONFERENCES

Members are reminded of the following conferences. Application forms are available for all of them on request to the Secretary.

Date	*Place*	*Subject*	*Organizers*
Mar. 23–26	Nottingham	Stress Analysis (all branches)	Stress Analysis Group
*April 1–2	Cambridge	Modern Structure Analysis	X-ray Analysis Group
*April 6–9	Nottingham	Physics of particle size analysis	Institute
*April 7–10	Cambridge	Luminescence	Electronics Group
April 12–13	London		Education Group

REVIEWS OF BOOKS

Fields and Waves in Modern Radio. By S. Ramo and J. R. Whinnery. (London : Chapman and Hall Ltd.) Pp. vii + 576. Price 70s.

The title of this excellent work is somewhat misleading in that the treatment of electromagnetic waves and fields (electrostatic and magnetic) which it comprises need not be restricted to the somewhat ill-defined and perhaps occasionally questionable activities embraced by the name of modern radio. Why hide the light of the excellent chapters 9–11, which describe wave guides and related matters in some 114 pages, under such a bushel ?

The standard of the work, which is necessarily highly mathematical, is that appropriate to final year honours students in physics and electrical engineering or to post-graduate lecture courses. It is, however, most gratifying to find the book self-contained in the sense that the meanings of, for example, curl and divergence are given clearly, and their use traced from first principles up to advanced applications. The relation between theory and practice is again clearly brought out in the lengthy study of stationary electric and magnetic fields, which includes a section on graphical field plotting (pp. 122–126) although relaxation methods as such do not appear to be introduced until, and then only briefly, much later in the book (p. 485).

The book contains twelve chapters ; the first three deal with fundamental matters (elementary theory of resonant circuits, Fourier series, wave systems and static fields). Then follow Maxwell's equations, and perhaps a little curiously, current distribution in conductors, and the calculation of self- and mutual impedances. Finally a group of five chapters, possible the best in the book, deals with propagation in un-bounded and bounded media (wave guides, cavities, etc.) and then the last chapter treats radiation from aerial systems. There are many useful examples interspersed here and there in the text.

This book can be recommended highly and, although there are several British books which deal as well, or perhaps even better, with the subject matter of parts of it, its comprehensiveness is unusual. For this reason its price cannot in these times be considered too high. Modern radio is, after all, quite an important subject and its interest as an academic discipline is by no means negligible.

J. D. Craggs.

Statistics for Technologists. By C. G. Paradine and B. H. P. Rivett. (London : English Universities Press Ltd.) Pp. 288. Price 25s.

In their preface, the authors make clear that the technologist of their title is to be assumed to have or to be working for a degree or higher national certificate in science or engineering, and that this

implies a standard in mathematics which has risen considerably in the last twenty years. They are explicitly writing for readers used to the mathematical presentation of some other subject, and they have produced a particularly well-designed introduction to theory and methods for all who are concerned with practical applications of statistics.

The underlying principle is that " the student who has followed the arguments—is more likely to be aware of assumptions made— ", and, by implication, less likely to apply the techniques in cases where these assumptions are invalid. There is need for this approach. The value of the book derives from the authors' realization that this requires a moderately high level of mathematical presentation which may nevertheless stop far short of absolute completeness and rigour, and that their intended readers will in fact have sufficient mathematical competence to comprehend it.

Where necessary, the authors assume a familiarity with calculus up to simple relations involving differentials and partial derivatives, though they quite properly (for their purpose) give values without proofs for $\Gamma(\frac{1}{2})$ and the like, and designedly forego such more sophisticated aids as moment generating functions.

The book proceeds from general and special frequency distributions, through Gaussian distributions and small-sample theory, to correlation and variance- and probit- analysis, with chapters on quality control, on sampling inspection, on error theory and on least-squares theory. Eight tables of the usual statistical functions are given (including random numbers).

There are plenty of good worked examples, and also of examples for exercise (with answers). The subject-matter of these is chosen from a wide range of applications whose obvious technological importance should appeal to and stimulate the student.

Even the less mathematical reader should benefit from the careful explanations, and might more safely derive procedural recipes (if he must) from this book, rather than from some others professedly of the " statistics without tears " variety. The statistical specialist may well be glad to have it available to lend to some of his associates.

T. H. O'Beirne.

What Happens in Singing. By Gerard Mackworth-Young. (London : Newman Neame Ltd.) Pp. 153. Price 12s. 6d.

This little book is by an experienced singer who confesses that he is no scientist. Nevertheless, his approach to his subject will appeal to those who are ; for throughout he asks the question, " what actually happens ? " His book recounts a search for truth, in a field where it is often obscured by physiological and physical misconceptions, and

by extravagant verbal imagery. The author's own writing is simple, and is augmented by a large number of line drawings and staff-notation illustrations, conveniently located in the margins, beside the relevant letterpress. The book is attractively produced. The omission of occasional words, and, in one case, of a whole line, will doubtless puzzle some readers.

About a half of the book is devoted to the action of those organs used in singing. These sections are sound and largely uncontroversial. "Registers" are defined in terms of modes of vibration of the vocal cords, a standpoint for which there is laryngoscopic support.

The sections on resonation, and on vowel sounds, will interest the physicist. Mr. Young describes tests, made with many well-known singers, to determine the part played by mouth and throat resonance. Referring to these tests, and to the work on vowel formants by Paget, Aiken, Fletcher and Miller, he concludes that vowel differentiation is practicable because these formants lie, in general, within the mouth resonance range; and he makes clear the physical reasons for the difficulties which singers experience with certain vowels on high notes. He concludes, too, that if a fundamental is produced, by any voice, in a range of about three and a half octaves, the sound will contain those partials which lie within a range of about one octave, the coverage of the throat cavity. As a result, low note fundamentals, and their early harmonics receive negligible resonation, the energy of the sound being contained almost entirely in one or more higher harmonics. This is, of course, well known; but Mr. Young's experiments—aided by Dr. D. B. Fry's work, with the same singers, using audio-frequency filters—adds much to what is known about the mechanism of this resonation.

The book deals cursorily with the interesting subject of the high voice formant, which has been attributed by some to laryngeal resonance, and by others to sinus effects. A surprising omission, too, in a book with the object of explaining "what happens," is any reference to vibrato. A 6–7 per second vibrato appears to be an essential requirement for good vocal quality, and some account of the way in which it arises would have been of interest.

Physicists may take exception to several statements in the book such as, for example, ". . . from the level of the vocal cords upwards there is no longer any air pressure, but only the phenomenon of sound." They may perhaps be surprised at the pains the author takes to dispose of the theory that sound is carried along on a current of air! It is, however, necessary to bear in mind that the book is intended, not for physicists but for singers and singing teachers. They should find it both interesting and useful.

H. W. FRENCH.

Applications are invited for positions in an Electronics Research Laboratory, for work on new developments in telecommunication systems and techniques. Academic qualifications and some experience an advantage.

Applications should be addressed to the **Personnel Manager, Standard Telecommunication Laboratories Ltd., Progress Way, Enfield, Middlesex.**

The British Cotton Industry Research Association. There are the following vacancies at the Shirley Institute for honours graduates and graduates with higher degrees. (1) **A junior physicist** for fundamental research on the stress-strain-time-moisture relations of cotton, rayon and synthetic materials. (2) **A junior physicist** for fundamental research on the absorption of gases and vapours by textile materials. (3) **A junior physicist,** research engineer, or textile technologist for fundamental research in carding and related processes preparatory to spinning. (4) **A junior physicist** or electronic engineer to undertake the development and application of instruments and techniques for physical measurements in the spinning of cotton and short staples of rayon and synthetic fibres. (5) **A junior physicist** for research on the friction and lubrication of textile materials. (6) **A junior physicist** or research engineer for research on weaving machinery. Knowledge of experimental stress analysis desirable. (7) **A junior mathematical statistician** to act as consultant on the design of experiments in the laboratories and in the mills, and to participate in the statistical work of the Institute. (8) **A more senior physicist** or textile technologist for fundamental and technical researches in the process of doubling. The successful candidate will be required to interest himself in the technical needs of the industry and, under guidance, to develop his researches accordingly. Industrial experience, not necessarily in the textile industry, is desirable. (9) **A more senior physicist** or research engineer for research on weaving machinery. Knowledge of experimental stress analysis desirable.

Applications are invited from those doing National Service, from students taking degrees in 1954, and from people who expect to be available at some time before the end of 1954. No experience of textiles is essential for any of these positions.

The starting salary for the junior positions is £500 to £550 for inexperienced graduates and may be up to £750 for those with research experience, a higher degree, or both. The starting salary for the more senior positions may be up to £900. All posts carry superannuation benefits under the F.S.S.U.

Apply, giving full particulars, to the Director, British Cotton Industry Research Association, Didsbury, Manchester 20.

Imperial Chemical Industries Limited, Dyestuffs Division, has a vacancy for a **physicist** in the Instrument Development Section of the Engineering Department. Candidates should have a thorough knowledge of classical physics and be interested in applying this to practical problems associated with the development of plant instruments, particularly for product analysis. After some years there will be opportunities for advancement in the broad fields of engineering for suitable candidates. Applicants should be aged 21–28 and have a first or second class honours degree. Applications in writing to Staff Department, Hexagon House, Blackley, Manchester, 9. Ref. INST.

Qualified **Physicist** required by South of England manufacturers of scientific equipment, for research work on the evaporation of metals and dielectrics in high vacuum, and the application of thin films. Previous work associated with high vacuum a distinct advantage. Permanent pensionable position. Commencing salary up to £750 p.a. according to age and experience. Full details of past experience required. Box A.V.57, The Institute of Physics, 47 Belgrave Square, London, S.W.1.

Ministry of Fuel and Power : Deputy Chief Scientific Officers. The Civil Service Commissioners invite applications from men for two pensionable posts, one in the Chief Scientist's Division in London to take charge of research and development work in connection with (1) prime movers and associated engineering projects, (2) certain gasification processes and their integration with other processes and (3) other miscellaneous projects concerned with the efficient utilization of energy and the development of new energy resources ; the other post is in the Safety in Mines Research Establishment at Sheffield to assist in the direction of research and engineering development on problems relating to safety in mines.

Age at least 35 on January 1, 1954. Candidates for the London post must possess a first or second class honours degree in engineering or an allied subject (or equivalent) and have had several years experience in a responsible position connected with mechanical or chemical engineering development work and associated research. Candidates for the Sheffield post must possess a first or second class honours degree in science or mathematics and have had considerable experience of the application of physical science to a wide range of problems. For both posts an exceptionally well qualified candidate but without the academic requirement may be considered.

Inclusive remuneration for the London post £1,950–£2,125 and for the Sheffield post £1,900–£2,100. Starting salary according to qualifications and experience.

Full particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S4297/54. Application forms to be returned by March 26, 1954.

National Coal Board invite applications for a post on the London Headquarters staff of their scientific department which will be concerned with the planning, supervision and co-ordination of research. The work will be mainly in the hydraulic and mechanical fields and will include the planning of large-scale experiments and the co-ordination of research data in forms suitable for use by engineers.

The appointment, which is superannuable, will be in the grade of Scientist I — £1,095 x £35 – £1,305 – £1,495, and London Location Allowance of £78 rising to £100 at the maximum is payable in addition. Some travelling will be necessary.

Apply in writing, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates) to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting this paper and marking envelope T7/747. Original testimonials should not be forwarded. Closing date March 27, 1954.

(*Continued on page iv*)

Applications are invited for senior positions in the research laboratories of a large manufacturing organization. Candidates should be academically qualified with several years experience in microwaves. The work comprises the research of waveguides and microwave antennas.

Applications should be addressed to the **Personnel Manager, Standard Telecommunication Laboratories Limited, Progress Way, Enfield, Middlesex.**

Applications are invited for the post of Head of the Ironmaking Division of the Association, the work of which includes research into all the processes of iron production from raw materials to hot iron in the ladle, or to cold pig. Candidates should have an honours degree in science or equivalent qualification, experience in chemical engineering and in research either industrial or academic. Starting salary from £1,450 upwards according to age, qualifications and experience, with superannuation under the F.S.S.U. The post, which will be located at the Imperial College of Science and Technology, London, may include on honorary lectureship in the Department of Chemical Engineering.

Written applications only quoting "Ironmaking" should be sent to the **Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W. 1,** before 31st March, 1954.

An appointment with good prospects is offered to a Science Graduate who is capable of conducting developments depending upon a knowledge of the physical properties of materials used in the construction of inductors and capacitors as embodied in telecommunication equipment. A knowledge of powder metallurgy is an essential qualification. Write giving details age, qualifications, experience and salary required to **Personnel Manager, Telephone Manufacturing Co. Ltd., Sevenoaks Way, St. Mary Cray, Kent.**

The **University of Reading** offers **Research Fellowships** for independent research in **Physics** and other subjects. The tenure of the Fellowships will date from October 1954. They are of value £600 p.a. and are normally available for three years. Candidates are expected to have had previous training in research to the standard required for Ph.D. degree.

Applicants must send 5 copies of the letter of application stating their age and the names of two referees, and setting forth details of the proposed research. The application must be accompanied by 5 copies each of the candidate's curriculum vitae and of one testimonial. Applications must be received before April 24, 1954, by the Registrar, from whom further particulars may be obtained.

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